Docket No.: 1594.1273

TITLE OF THE INVENTION

ROTARY COMPRESSOR

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of Korean Application No. 2003-17994, filed March 22, 2003, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates, in general, to rotary compressors and, more particularly, to a variable capacity rotary compressor which has two compression chambers so as to alternately perform a refrigerant compression stroke and an idle stroke in the two compression chambers in accordance with a change in a rotating direction of a rotating shaft.

2. Description of the Related Art

[0003] As is well known to those skilled in the art, a rotary compressor is used as a refrigerant compression unit in a refrigerant circulation circuit of a refrigerating system, such as an air conditioner, a heater, or a refrigerator which controls a temperature of air in a desired space. In the refrigerant circulation circuit, the rotary compressor sucks, compresses and discharges the refrigerant.

[0004] A refrigerant compression capacity of the rotary compressor may be controlled in accordance with a change in conditions of a target space. The rotary compressors are provided such that the refrigerant compression capacity thereof is controllable, are so-called "variable capacity rotary compressors". Particularly in a case of multiunit air conditioners each having several indoor units operated in conjunction with one outdoor unit, use of the variable capacity

compressors is necessary. In the related art, the variable capacity of the rotary compressors is accomplished by use of electronic elements, such as inverter motors or blushless direct current (BLDC) motors, in compressors. The electronic elements electronically control a capacity of the rotary compressors.

[0005] However, the variable capacity rotary compressors having the inverter motors or the BLDC motors are problematic in that to use control circuit boards to control an operation of the inverter motors or the BLDC motors is necessary, thus increasing a production cost of the variable capacity rotary compressors due to the control circuit boards being expensive. Further, due to electric power consumption of the control circuit boards, the power consumption of the variable capacity rotary compressors is undesirably increased. In an effort to overcome the problems experienced in the conventional variable capacity rotary compressors having the electronic elements, such as the inverter motors or the BLDC motors, the inventors of the present invention proposed a rotary compressor, the refrigerant compression capacity of which is varied as desired between two stages by use of a mechanical mechanism.

SUMMARY OF THE INVENTION

[0006] Accordingly, it is an aspect of the present invention to provide a variable capacity rotary compressor of which a refrigerant compression capacity is varied as desired between four stages by use of a mechanical mechanism.

[0007] Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

[0008] The above and/or other aspects of the present invention are achieved by providing a rotary compressor, having a rotating shaft comprising first and second eccentric parts; a reversible motor to rotate the rotating shaft in a first direction or a second direction; a first cylinder comprising a first compression chamber in which a refrigerant compression stroke or an idle stroke is performed in accordance with a rotating direction of the first eccentric part of the rotating shaft; a first intake port to suck a refrigerant into the first compression chamber; and a

first exhaust port to discharge the refrigerant from the first compression chamber after the refrigerant is compressed; a second cylinder comprising a second compression chamber in which the refrigerant compression stroke or the idle stroke is performed in accordance with the rotating direction of the second eccentric part of the rotating shaft, such that first and second compression chambers alternately perform the compression stroke and the idle stroke; a second intake port to suck the refrigerant into the second compression chamber; and a second exhaust port to discharge the refrigerant from the second compression chamber after the refrigerant is compressed; a first sub-path which allows a predetermined point of the first compression chamber to communicate with the first intake port so as to control a compression capacity of the first compression chamber; and a path control unit to control an opening ratio of the first sub-path.

[0009] In the rotary compressor, the first sub-path is a first sub-path pipe provided to allow the predetermined point of the first compression chamber to communicate with the first intake port, or a first sub-path groove provided in the first cylinder to allow the predetermined point of the first compression chamber to communicate with the first intake port.

[0010] The rotary compressor further comprises a second sub-path which allows a predetermined point of the second compression chamber to communicate with the second intake port so as to control a compression capacity of the second compression chamber, an opening ratio of the second sub-path being controlled by the path control unit.

[0011] In the rotary compressor, the second sub-path is a second sub-path pipe provided to allow the predetermined point of the second compression chamber to communicate with the second intake port, or a second sub-path groove provided in the second cylinder to allow the predetermined point of the second compression chamber to communicate with the second intake port.

[0012] In the rotary compressor, the path control unit includes first and second path control units which control opening ratios of the first and second sub-paths, respectively.

[0013] The first and second compression chambers have different compression capacities.

[0014] The above and/or other aspects are achieved by providing a rotary compressor, having a rotating shaft; a reversible motor to rotate the rotating shaft in a first direction or a second direction; first and second compression chambers in which a refrigerant compression stroke and an idle stroke are alternately performed in accordance with a rotating direction of the rotating shaft; a first sub-path which allows a predetermined point of the first compression chamber to communicate with a refrigerant intake side of the first compression chamber so as to control a compression capacity of the first compression chamber; a second sub-path which allows a predetermined point of the second compression chamber to communicate with a refrigerant intake side of the second compression chamber so as to control a compression capacity of the second compression chamber; and a path control unit to control opening ratios of the first and second sub-paths.

[0015] In the rotary compressor, a capacity ratio of the first and second compression chambers in a range of about is 2.1:1 to 1.9:1.

[0016] The predetermined point of the first compression chamber is determined such that a compression capacity of the first compression chamber, in a state that the first sub-path is opened by the path control unit, is reduced by about 20% to 30%, in comparison with the compression capacity of the first compression chamber in a state that the first sub-path is closed.

[0017] The predetermined point of the second compression chamber is determined such that a compression capacity of the second compression chamber, in a state that the second sub-path is opened by the path control unit, is reduced by about 40% to 60%, in comparison with the compression capacity of the second compression chamber in a state that the second sub-path is closed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] These and/or other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the preferred embodiments, taken in conjunction with the accompanying drawings of which:

[0019] FIG. 1 is a longitudinal sectional view of a variable capacity rotary compressor, according to a first embodiment of the present invention;

[0020] FIG. 2 is a perspective view of a compression unit of the rotary compressor of FIG. 1;

[0021] FIG. 3 is an exploded perspective view of the compression unit of FIG. 2;

[0022] FIGS. 4 and 5 are latitudinal sectional views taken along the line I-I showing and operation of the rotary compressor of FIG. 1;

[0023] FIGS. 6 and 7 are latitudinal sectional views taken along the line II-II showing an operation of the rotary compressor of FIG. 1; and

[0024] FIG. 8 is a latitudinal sectional view of a variable capacity rotary compressor, according to a second embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] Reference will now be made in detail to the present preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout.

[0026] FIG. 1 is a longitudinal sectioned view of a variable capacity rotary compressor, according to a first embodiment of the present invention. FIG. 2 is a perspective view of a compression unit of the rotary compressor of FIG. 1. FIG. 3 is an exploded perspective view of the compression unit of FIG. 2.

[0027] As shown in FIGS. 1 to 3, the variable capacity rotary compressor 1 according to the first embodiment of the present invention includes a hermetic casing 100, with a drive unit 200 and a compression unit 300 installed in the hermetic casing 100. The drive unit 200 generates a rotating force when an electric current is applied to the drive unit 200. The compression unit 300 is coupled to the drive unit 200 through a rotating shaft 21 so as to compress refrigerant by the rotating force of the drive unit 200.

[0028] The drive unit 200 includes the rotating shaft 21 having first and second eccentric parts 21a and 21b. The drive unit 200 also includes a rotor 22 and a stator 23. The rotor 22 is a cylindrical body fitted over an upper portion of the rotating shaft 21 to electromagnetically rotate in cooperation with the stator 23. The stator 23 is fixed to an inner surface of the hermetic casing 100 while surrounding the rotor 22, with an annular gap defined between the rotor 22 and the stator 23. The stator 23 is wound with a coil that is connected to an external electric power source, so that the stator 23 produces a magnetic field to electromagnetically rotate the rotor 22. In the drive unit 200, the rotor 22 and the stator 23 comprise a reversible drive motor that is rotatable in either a clockwise direction or a counter clockwise direction.

[0029] The compression unit 300 includes first and second cylinders 31 and 32. The first cylinder 31 defines therein a first compression chamber 31a which receives the first eccentric part 21a of the rotating shaft 21 therein so as to perform a compression stroke during a forward rotation of the rotating shaft 21, and an idle stroke during a reverse rotation of the rotating shaft 21. The second cylinder 32 defines therein a second compression chamber 32a which receives the second eccentric part 21b of the rotating shaft 21 therein and has a compression capacity smaller than that of the first compression chamber 31a (about a half of the compression capacity of that of the first compression chamber 31a). The second compression chamber 32a performs an idle stroke during the forward rotation of the rotating shaft 21, and a compression stroke during the reverse rotation of the rotating shaft 21. The first and second compression chambers 31a and 32a thus alternately perform the compression and idle strokes. A first roller piston 33 is fitted over the first eccentric part 21a of the rotating shaft 21 in the first compression chamber 31a, a predetermined first gap defined between the first roller piston 33 and the first eccentric part 21a to be eccentric to a side. A second roller piston 34 is fitted over the second eccentric part 21b of the rotating shaft 21 in the second compression chamber 32a, a predetermined second gap defined between the second roller piston 34 and the second eccentric part 21b to be eccentric to another side. A first cam bush 35 having an eccentric shape is fitted in the first eccentric gap between the first eccentric part 21a and the first roller piston 33 in the first compression chamber 31a. A second cam bush 36 having an eccentric shape is fitted in the second eccentric gap between the second eccentric part 21b and the second roller piston 34 in the second compression chamber 32a. An upper flange 37

hermetically seals an upper end of the first compression chamber 31a while supporting an intermediate portion of the rotating shaft 21. An intermediate plate 38 is provided between the first and second cylinders 31 and 32 so as to hermetically seal both a lower end of the first compression chamber 31a and an upper end of the second compression chamber 32a. A lower flange 39 hermetically seals a lower end of the second compression chamber 32a while supporting a lower end of the rotating shaft 21.

[0030] During the forward rotation of the rotating shaft 21, the first cam bush 35 causes an eccentric rotation of the first roller piston 33 to allow the compression stroke to be performed in the first compression chamber 31a. However, during the reverse rotation of the rotating shaft 21, the first cam bush 35 causes a concentric rotation of the first roller piston 33 to allow the idle stroke to be performed in the first compression chamber 31a. The second cam bush 36 causes a concentric rotation of the second roller piston 34 during the forward rotation of the rotating shaft 21 to allow the idle stroke to be performed in the second compression chamber 32a. However, during the reverse rotation of the rotating shaft 21, the second cam bush 36 causes an eccentric rotation of the second roller piston 34 to allow the compression stroke to be performed in the second compression chamber 32a.

[0031] The first cylinder 31 has a first intake port 31b, a first exhaust port 31c, and a first sub-path groove 31d. The first intake port 31b sucks the refrigerant into the first compression chamber 31a, while the first exhaust port 31c discharges the refrigerant from the first compression chamber 31a after the refrigerant is compressed. The first sub-path groove 31d forms a first sub-path, which allows the first intake port 31b to communicate with a point "A" of the first compression chamber 31a, so as to control a capacity of the first compression chamber 31a. In a same manner, the second cylinder 32 has a second intake port 32b, a second exhaust port 32c, and a second sub-path groove 32d. The second intake port 32b sucks the refrigerant into the second compression chamber 32a, while the second exhaust port 32c discharges the refrigerant from the second compression chamber 32a after the refrigerant is compressed. The second sub-path groove 32d forms a second sub-path which allows the second intake port 32b to communicate with a point "B" of the second compression chamber 32a so as to control a capacity of the second compression chamber 32a.

[0032] The variable capacity rotary compressor has a path control unit driven by a solenoid unit to control opening ratios of the first and second sub-path grooves 31d and 32d. As shown in FIGS. 2 and 3, the path control unit is fabricated as two separate units, first and second path control units 40a and 40b which separately control the opening ratios of the first and second sub-path grooves 31d and 32d. The first path control unit 40a controls the opening ratio of the first sub-path groove 31d and the second path control unit 40b controls the opening ratio of the second sub-path groove 32d. However, the path control unit may be a single unit that controls the opening ratios of both of the first and second sub-path grooves 31d and 32d.

[0033] A capacity ratio of the first, second, third and fourth stages of the variable capacity rotary compressor 1 may be set to, for example, 4:3:2:1, and to accomplish the capacity ratio of 4:3:2:1 of the four stages, the first and second compression chambers 31a and 31b have a capacity ratio of 2:1. However, the capacity ratio of the first, second, third and fourth stages of the variable capacity rotary compressor 1 and the capacity ratio of the first and second compression chambers 31a and 32a may change from the above-mentioned ratios if the variable capacity rotary compressor 1 varies in a refrigerant compression capacity thereof between the four stages. When the capacity ratio of the first, second, third and fourth stages of the variable capacity rotary compressor 1 is set to 4:3:2:1, as described above, the capacity ratio of the first and second compression chambers 31a and 31b may be set in a range of about 2.1:1 to 1.9:1, in consideration of machining allowances and other conditions of the variable capacity rotary compressor 1.

[0034] To produce the variable capacity rotary compressor 1 having the capacity ratio of the first, second, third and fourth stages set to 4:3:2:1, the point "A" in the first compression chamber 31a is determined as follows. The point "A" in the first compression chamber 31a is determined such that when the first sub-path groove 31d is opened under the control of the first path control unit 40a, a variable capacity of the first compression chamber 31a is reduced by 25%, compared with a capacity of the first compression chamber 31a in a state that the first sub-path groove 31d is closed. However, a capacity reduction ratio of the first compression chamber 31a may change from the above-mentioned ratio, if the changed capacity reduction ratio of the first compression chamber 31a allows the rotary compressor to vary in a capacity thereof between the first to fourth stages. When the capacity ratio of the first, second, third and

fourth stages of the variable capacity rotary compressor 1 is set to 4:3:2:1, as described above, the point “A” in the first compression chamber 31a may be determined such that the variable capacity of the first compression chamber 31a, in a state that the first sub-path groove 31d is opened, is reduced in a range of about 20% to 30%, compared with the capacity of the first compression chamber 31a in the state that the first sub-path groove 31d is closed.

[0035] To produce the variable capacity rotary compressor 1 having the capacity ratio of the second to fourth stages set to 4:3:2:1, the point “B” in the second compression chamber 32a is determined as follows. The point “B” in the second compression chamber 32a is determined such that when the second sub-path groove 32d is opened under the control of the second path control unit 40b, a variable capacity of the second compression chamber 32a is reduced by 50% compared with the capacity of the second compression chamber 32a in a state that the second sub-path groove 32d is closed. However, a capacity reduction ratio of the second compression chamber 32a may change from the above-mentioned ratio, if the changed capacity reduction ratio of the second compression chamber 32a allows the rotary compressor to vary in a capacity thereof between the first to fourth stages. When the capacity ratio of the first, second, third and fourth stages of the variable capacity rotary compressor 1 is set to 4:3:2:1, as described above, the point “B” in the second compression chamber 32a may be determined such that the variable capacity of the second compression chamber 32a, in a state that the second sub-path groove 32d, is opened is reduced in a range of about 40% to 60%, in comparison with the capacity of the second compression chamber 32a in the state that the second sub-path groove 32d is closed.

[0036] The operation and effect of the variable capacity rotary compressor having the above-mentioned construction will be described herein below.

[0037] The variable capacity rotary compressor 1 is used as a refrigerant compression unit in a refrigerant circulation circuit of a refrigerating system, such as an air conditioner, a heater, or a refrigerator that controls a temperature of air in a target space.

[0038] To appropriately and effectively control the temperature of air in the target space, the refrigerant compression capacity of the rotary compressor is required to change in accordance with the present temperature of the space.

[0039] The variable capacity rotary compressor 1 is operated as follows in the first to fourth stage modes wherein the rotary compressor achieves different compression capacities, and stage numbers of the variable capacity rotary compressor 1 in the following description are designated in order of a scale of the capacities from a largest capacity to a smallest capacity.

[0040] 1. Operation of the variable capacity rotary compressor 1 in a first stage mode

[0041] In a first stage mode, the reversible motor of the drive unit 200 rotates the rotating shaft 21 in a forward direction, as shown in FIG. 4, so that the first roller piston 33 eccentrically rotates by an operation of both the first eccentric part 21a of the rotating shaft 21 and the first cam bush 35. The first roller piston 33 in the first stage mode performs a compression stroke in the first compression chamber 31a, while the second roller piston 34 in the first stage mode concentrically rotates to perform an idle stroke in the second compression chamber 32a. In the first stage mode, the first path control unit 40a closes the first sub-path groove 31d, and the variable capacity rotary compressor 1 achieves a largest refrigerant compression capacity in the first stage mode.

[0042] 2. Operation of the variable capacity rotary compressor 1 in the second stage mode

[0043] In the second stage mode, the reversible motor of the drive unit 200 rotates the rotating shaft 21 in the forward direction, as shown in FIG. 5, so that the first roller piston 33 eccentrically rotates by the operation of both the first eccentric part 21a of the rotating shaft 21 and the first cam bush 35. The first roller piston 33 performs the compression stroke in the first compression chamber 31a, while the second roller piston 34 concentrically rotates to perform the idle stroke in the second compression chamber 32a, in a same manner as that described for the first stage mode. However, in the second stage mode different from in the first stage mode, the first path control unit 40a opens the first sub-path groove 31d, so that an effective refrigerant compression stroke performed by the first roller piston 33 in the first compression chamber 31a starts at the point "A" of the first compression chamber 31a. The variable capacity rotary

compressor 1 in the second stage mode achieves a compression capacity equal to 75% of the capacity expected in the first stage mode.

[0044] 3. Operation of the variable capacity rotary compressor 1 in the third stage mode

[0045] In the third stage mode, the reversible motor of the drive unit 200 rotates the rotating shaft 21 in a reverse direction, as shown in FIG. 6, so that the first roller piston 33 concentrically rotates to perform the idle stroke in the first compression chamber 31a. However, in the second compression chamber 32a during the third stage mode, the second roller piston 34 eccentrically rotates by an operation of both the second eccentric part 21b of the rotating shaft 21 and the second cam bush 36. The second roller piston 34 performs the compression stroke in the second compression chamber 32a. The second path control unit 40b in the third stage mode closes the second sub-path groove 32d, so that the variable capacity rotary compressor 1 in the third stage mode achieves the compression capacity which is equal to 50% of the capacity expected in the first stage mode, and which is equal to 75% of the capacity expected in the second stage mode.

[0046] 4. Operation of the variable capacity rotary compressor 1 in a fourth stage mode

[0047] In the fourth stage mode, the reversible motor of the drive unit 200 rotates the rotating shaft 21 in the reverse direction, as shown in FIG. 7, so that the first roller piston 33 concentrically rotates to perform the idle stroke in the first compression chamber 31a, while the second roller piston 34 eccentrically rotates by the operation of both the second eccentric part 21b of the rotating shaft 21 and the second cam bush 36. The second roller piston 34 performs the compression stroke in the second compression chamber 32a, in a same manner as that described for the third stage mode. However, in the fourth stage mode which is different from in the third stage mode, the second path control unit 40b opens the second sub-path groove 32d, so that the effective refrigerant compression stroke performed by the second roller piston 34 in the second compression chamber 32a starts at the point "B" of the second compression chamber 32a. The variable capacity rotary compressor 1 in the fourth stage mode achieves a compression capacity that is equal to 25% of the capacity expected in the first stage mode, that

is equal to 33% of the capacity expected in the second stage mode, and that is equal to 50% of the capacity expected in the third stage mode.

[0048] As described above, the variable capacity rotary compressor 1 varies in the refrigerant compression capacity thereof between the four stages such that the first to fourth stages have a capacity ratio of 4:3:2:1. The capacity ratio of the first, second, third and fourth stages of the variable capacity rotary compressor 1 is not limited to the above-mentioned ratio, but may be set to any other ratio without affecting an operation of the present invention.

[0049] FIG. 8 is a latitudinal sectioned view of a variable capacity rotary compressor 2, according to a second embodiment of the present invention. As shown in FIG. 8, the second embodiment alters a construction of the first and second sub-paths and the first and second path control units provided in the variable capacity rotary compressor 2 to control a refrigerant compression capacities of the first and second compression chambers 31a and 32a. That is, the first and second sub-paths are, respectively, formed by a first sub-path pipe 51a which allows the first compression chamber 31a to communicate with the first intake port 31b, and a second sub-path pipe 51b which allows the second compression chamber 32a to communicate with the second intake port 32b. To control opening ratios of the first and second sub-path pipes 51a and 51b, the first and second path control units 50a and 50b are provided in the variable capacity rotary compressor 2.

[0050] As described above, the variable capacity rotary compressor which varies in the refrigerant compression capacity thereof as desired between four stages such that first to fourth stages by use of a mechanical mechanism, so that the variable capacity rotary compressor 2 may be used in a refrigerating system, such as an air conditioner (particularly, a multiunit air conditioner), a heater, or a refrigerator required to be equipped with a variable capacity compressor.

[0051] In addition, the variable capacity rotary compressor does not need an expensive control circuit board which must be used in conventional electronically controlled variable capacity compressors to control an operation of an inverter motor or a BLDC motor. The

variable capacity rotary compressor reduces a production cost of the variable capacity rotary compressors.

[0052] Furthermore, the variable capacity rotary compressor may reduce power consumption compared with the conventional electronically controlled variable capacity compressors.

[0053] Although a few preferred embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents. For example, the rotary compressor of the present invention may be provided with only one of the first and second sub-paths. In such a case, the capacity of the rotary compressor is varied between three stages, that is, first to third stages.